Analze the Impact of Discretization on the Structure of the Simulation Result

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Abstract— This paper presents an analysis of the impact of digitization of the antenna structure on obtained simulation results for the two most popular methods of calculation MoM and FDTD. Simulations were performed for linear and microstrip antennas.

1. INTRODUCTION

The demands for modern radio systems forced to look for new solutions in constructions of antennas [11, 15, 17, 18, 25]. Antennas are an essential element of the plurality of measurement [5–8, 10, 19–21]. This requires conduct many tests and measurements

Research of antennas are a complex, lengthy and relatively expensive [3, 4]. In the laboratory, often we don't have possible to investigate the effect of the relationship between physical parameters of the antenna and its electrical parameters and characteristics of the radiation. This is due to the fact that almost always we must change the antenna physical parameters (dimensions) leads to irreversible structural changes of the antenna, which is extremely expensive. In microstrip antennas are important parameters of the dielectric, which can be explored to measure in accordance with the methods described in the [1, 2, 9, 12, 16]. Radiations pattern of the antenna can also be determined from measurements of the near field [13, 14].

With using a variety of simulation environments, we can study the antenna of any size and shap. This article uses the software Numerical Electromagnetics Code (Nec2d) and CST STUDIO SUITE for analyzing the electromagnetic response of the antenna structure at any distance from the Earth, or without taking into account its impact 4Nec2 program based on the method of moments MoM and CST STUDIO SUITE program based on the finite difference time domain FDTD

2. DISCRETIZATION OF STRUCTURE IN MOM AND FDTD METHODS

The main condition for obtaining correct results of simulations using the method of moments MoM or FDTD is discretization of antenna structure. In the case of using the MoM method structure is mapped using thin wires. Conditions to be met by the dimensions of wires must meet the conditions shown in Figure 2. When using the FDTD method for analyzing the structure of the analyzed antenna is mostly mapped using cubes (Figure 1) The value limit is the size of the cell (length guide), which should not exceed 0.1 wave length because it is the limit of error generation.

3. ANALYSIS OF THE INFLUENCE OF ANTENNA STRUCTURE DISCRETIZATION ON THE SIMULATION RESULT FOR MOM

The simulation was carried out for 12-element Yagi Uda-antenna. This antenna operates at the frequency $f_0 = 435\,\text{MHz}$. Parameter that has been changed in the process of simulation is the

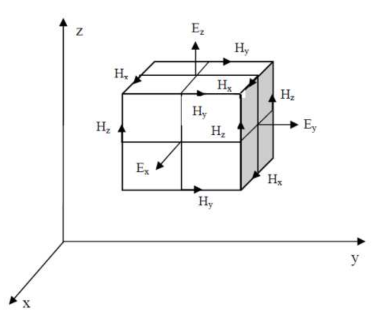

Figure 1: Distribution vectors electric and magnetic field in a cubic cell of the grid Yee'a.

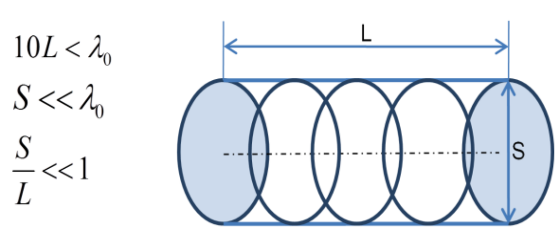

Figure 2: Terms of correct discretization cable in order to get the correct results using MoM (Method of Moments).

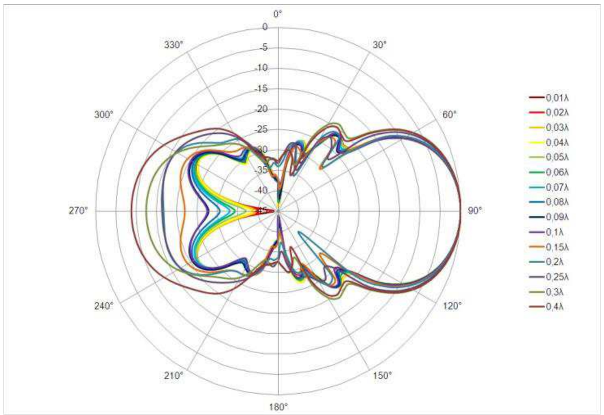

Figure 3: Radiation pattern of Uda-Yagi antenna — vertical polarization (V).

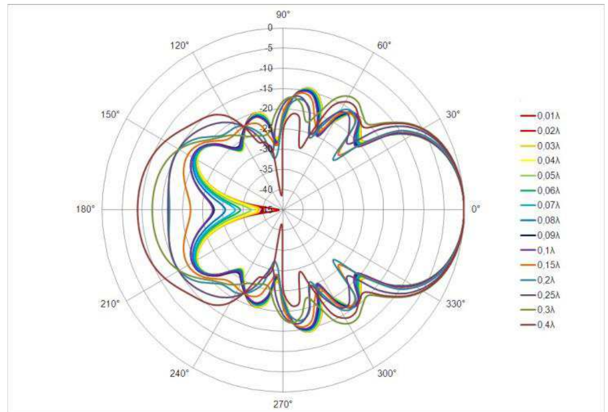

Figure 4: Radiation pattern of Uda-Yagi antenna — horizontal polarization (H).

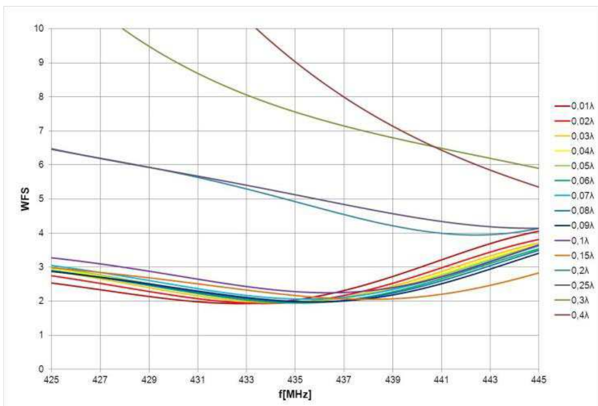

Figure 5: VSWR of Uda-Yagi antenna as a function of dis-cretization of the structure.

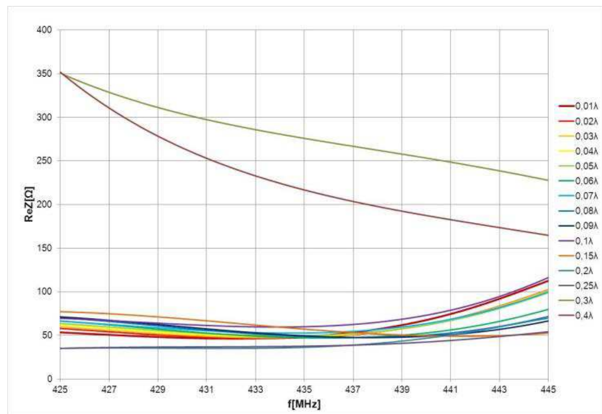

Figure 6: Resistance of Uda-Yagi antenna as a function of discretization of the structure.

degree of discretization of the structure (changing cell size). Cell Size test points varied in the range of 0.01λ to 0.4λ. As a result of the simulation were calculated radiation pattern of the test antanna with vertical polarization (V), horizontal polarization (H) and f the most important parameters such as the WFS real and imaginary impedance, width of main lobe(-3 dB), frequency and duration of work simulation.

Of the two above-described characteristics of the radiation pattern in the vertical polarization (V) (Figures 3 and 4), we can see that the cell size has no significant effect on the radiation of the main lobe. In the case of the radiation lobe reverse impact is significant. To the distribution 0.1λ the radiation of reverse lobe slightly changes its shape. On the other hand above 0.1λ it can be seen significant increase radiation of reverse lobe. For division of structure 0.4λ we have increase value of reverse lobe equal to 11 dBi.

As can be seen simulation shows that the characteristics of the standing wave ratio (Figures 5 and 6) to a value 0.08λ shows a normal waveform characteristics, since the minimum value of VSWR fall on the 435 MHz frequency which coincides with the resonant frequency of the antenna test. In contrast, above the misrepresentation occurs 0.08λ results. Next characteristic (Figure 8) shows the dependence the input resistance of the antenna from the frequency.

The input resistance of the antenna to the 0.25λ value has the correct shape. For discretization below 0.25λ for the 435 MHz resonance frequency the input resistance falls within the range $50\,\Omega$. When the value is above 0.25λ we can see significant errors.

4. ANALYSIS OF THE INFLUENCE OF ANTENNA STRUCTURE DISCRETIZATION ON THE SIMULATION RESULT FOR FDTD

To analyze the impact of digitization on the structure of the simulation results using the FDTD method, we made the simulation of a rectangular microstrip antenna radiator shown in (Figures 7 and 8). This antenna operates at the resonance frequency $f = 1.79$ GHz. Parameter that has been changed in the process of simulation is the size of a cubic grid Yee'a.

As can be seen simulation shows that the characteristics of the standing wave ratio (Figure 9) to the size of a cell below 0.1λ shows a correct value. The measurement results confirm the results of the simulation. In both cases, the WFS reaches the minimum value for $f = 1.79\,\text{GHz}$. With the increase in cell size above 1.1 simulation results are burdened with more and bigger mistake.

The resistance of the antenna (Figure 10) for the Yee cell sizes below 0.1. takes the correct value.

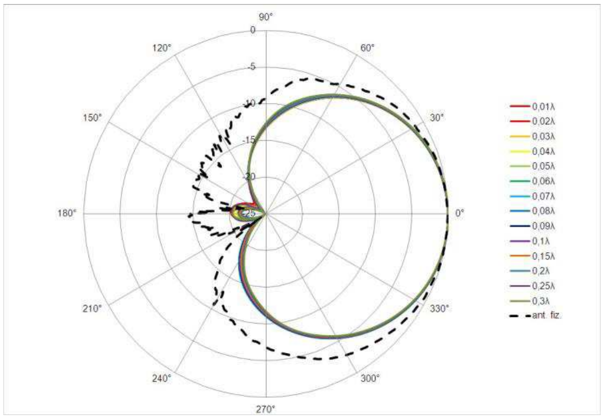

Figure 7: Section of building with the marked first measuring position. Measurement of attenuation between room 1.12 and corridor through closed door.

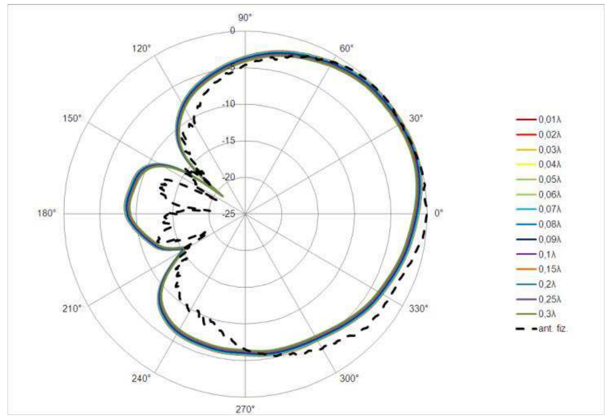

Figure 8: Attenuation received as a result of measurement through gypsum-cardboard wall between room 1.12 and corridor.

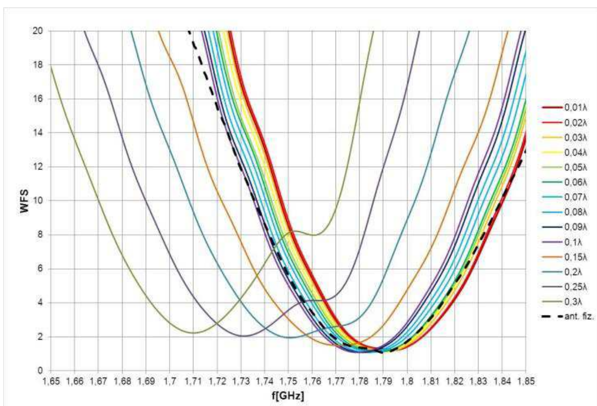

Figure 9: VSWR of microstrip antenna with rectangular patch as a function of discretization of the structure.

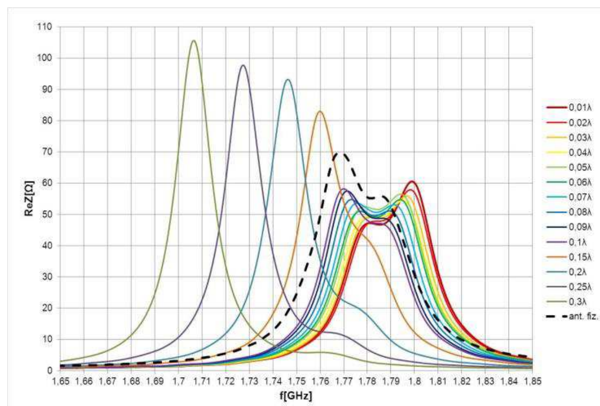

Figure 10: Resistance of microstrip antenna with rectangular patch as a function of discretization of the structure.

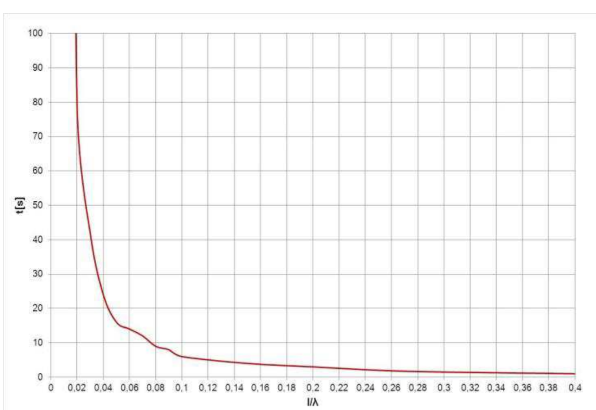

Figure 11: Charakterystyka czasu trwania symulacji anteny Yagi-Uda w zależności od stopnia dyskretyzacji struktury.

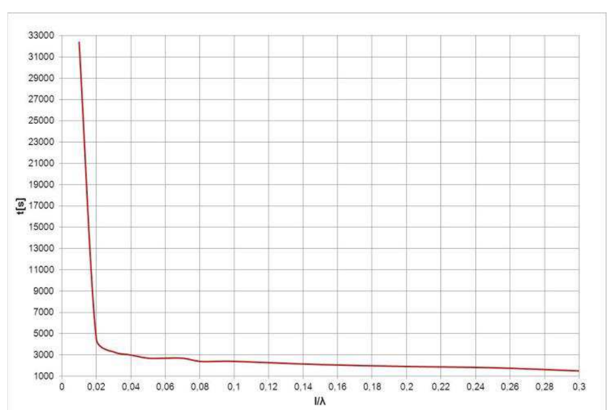

Figure 12: Charakterystyka czasu trwania symulacji anteny mikropaskowej z prostokątnym promiennikiem.

Wskazuje to na dobre dopasowanie impedancji wejściowej do impedancji przewodu równej $50\,\Omega$. When the value is above 0.1λ obtained results differ significantly from the results of measurements and the simulation results.

For Yee cell size smaller than 0.04λ duration of the simulation begins to grow exponentially.

5. CONCLUSIONS

Analyzing the structure of the antenna using MoM moments can be concluded that the size of the cells in the simulation has a very large impact on the results achieved. The size of the cells has a very large impact on the parameters of the tested antennas and less on the characteristics of the radiation. The radiation characteristics of the biggest changes can be seen in the back-lobe level. For antennas with simple structure simulation duration is not too long. It does not pay to increase the size of the cells to simulate as soon as possible reducing the duration of the simulation reduce the accuracy of the calculation, resulting in the generation of errors and inaccuracies. The optimal distribution of antenna structures to simulate 0.05λ value. This is the result of a compromise between the duration of the simulation and the accuracy of the results.

Tested antenna structure with the using finite difference time domain FDTD show that the size of the cubic cell has less impact on the simulation process than is the case method of moments MoM. Simulation durations are very long, e.g., for microstrip antenna with a rectangular radiator for a cubic grid size 0.01λ imulation lasted more than nine hours. In contrast, for comparison, the same antenna simulated for the cubic grid size 0.1λ lasted 30 minutes.

The time difference is enormous, but this difference can be seen in the results of the simulation. For values 0.1λ and 0.01λ the results were not different from each other in significant ways. As you can see the duration plays a very important role. The optimal size of a cubic grid for the analyzed antenna is 0.08λ value. For the 0.08λ simulation takes about 35 min with very small errors. You may also note that the antenna measurements carried out in an anechoic chamber are similar with the results of the simulation carried out in the CST Studio Suite.

ACKNOWLEDGMENT

The project is financed from the NCBiR means within Agreement No. 0024/R/ID2/2012/02 in the years 2012–2015.

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